Formosa Journal of Applied Sciences (FJAS)
Vol. 5, No. 7 2026: 1513-1522

Implementation of a Simple Hydroponic System for Water Spinach (*Ipomoea reptans*) Cultivation as an Applied Learning Model at an Agricultural Training Center (P4S)

Dewa Gede Agung Mahagiri[1]*, I Gusti Bagus Udayana[2], Made Sri Yuliartini[3]
Universitas Warmadewa
Corresponding Author: Dewa Gede Agung Mahagiri
dewaajus1901@gmail.com

ARTICLEINFO

Keywords: Simple Hydroponic System, Water Spinach (*Ipomoea Reptans*), Applied Cultivation, Agricultural Training Center (P4S), Land-Limited Farming

Received : 14, March
Revised : 16, May
Accepted: 18, July

ABSTRACT

This study aims to analyze the implementation of a simple hydroponic system for water spinach (*Ipomoea reptans*) cultivation at P4S Sedana Sari as an applied learning and production model under limited land conditions. The study examines key concepts including cultivation stages, nutrient management, plant growth response, and technical constraints. A descriptive qualitative approach was employed through direct field observation conducted in mid-2024, covering seedling preparation, transplanting, maintenance, and harvesting stages. The findings indicate that the simple hydroponic system supported uniform vegetative growth, healthy plant appearance, and low pest disturbance. These results suggest that simple hydroponic systems are suitable for small-scale application and agricultural training centers, contributing to sustainable cultivation practices in land-limited environments.

DOI prefik: https://doi.org/10.55927/fjas.v5i7.77
ISSN-E: 2962-6447
https://journalfjas.my.id/index.php/fjas

INTRODUCTION

Leafy vegetables play a strategic role in supporting food security and improving community nutrition, particularly in developing countries. According to Nazaruddin (2003), vegetables such as water spinach (*Ipomoea reptans*) contribute significantly to daily dietary intake due to their vitamin, mineral, and fiber content. Water spinach is widely cultivated and consumed in Indonesia because of its short production cycle and relatively simple cultivation requirements. Despite its potential, conventional cultivation of water spinach increasingly faces land availability constraints. Rapid land conversion for urban development and non-agricultural purposes has reduced the area of productive farmland. FAO (2017) reported that land scarcity has become a global challenge that threatens the sustainability of food production systems, particularly for horticultural commodities that rely on continuous land access.

Hydroponic cultivation has emerged as a practical alternative to address these constraints. Lingga (2002) explained that hydroponic systems enable plants to grow without soil by supplying nutrients directly to the root zone, allowing for more efficient nutrient uptake and water use. Sutiyoso (2006) further emphasized that simple hydroponic systems are suitable for small-scale application due to their low cost, ease of construction, and adaptability to limited land conditions. Water spinach is known to adapt well to soilless cultivation systems when nutrient availability is properly managed. According to Rosliani and Sumarni (2005), hydroponic cultivation of leafy vegetables reduces exposure to soil-borne pathogens, resulting in healthier plant growth and improved crop hygiene. This characteristic makes hydroponic systems particularly relevant for training and demonstration purposes.

In addition to land scarcity, increasing public awareness of food safety has encouraged the adoption of cultivation systems capable of producing cleaner and healthier vegetables. Consumers are becoming more concerned about pesticide residues and environmental sustainability, leading to higher demand for vegetables cultivated using environmentally friendly production methods. Hydroponic cultivation provides an alternative production system that minimizes direct contact between plants and contaminated soil while allowing better control over water and nutrient management. Consequently, hydroponic technology has gained considerable attention not only among commercial producers but also within educational and community-based agricultural institutions.

The development of hydroponic technology is also closely related to the concept of sustainable agriculture. Efficient use of water, reduced dependence on agricultural land, and the possibility of year-round cultivation make hydroponic systems compatible with modern agricultural development strategies. Although commercial hydroponic production often requires relatively high investment, simple hydroponic systems using affordable local materials can significantly reduce production costs while maintaining satisfactory crop performance. Therefore, introducing this technology through agricultural training institutions is expected to improve farmers’ knowledge and encourage wider technology adoption.

Agricultural training centers such as P4S (Center for Agricultural and Rural Self-Training) play an important role in disseminating appropriate agricultural technologies. FAO (2017) highlighted that applied, field-based learning environments are effective platforms for accelerating technology adoption among farmers. However, most previous studies on hydroponic cultivation of water spinach have focused on experimental yield measurements or nutrient formulation trials, while limited attention has been given to implementation-based evaluations in training institutions. Therefore, this study contributes to the enrichment of knowledge by examining the applied implementation of a simple hydroponic system for water spinach cultivation at a P4S. By focusing on cultivation stages, plant growth response, nutrient management, and technical constraints, this study provides practical insights into the feasibility of hydroponic systems as applied learning models under land-limited conditions, with the aim of supporting sustainable horticultural practices and agricultural capacity building.

LITERATURE REVIEW

Hydroponic cultivation has been increasingly promoted as an alternative agricultural system in response to land limitations and environmental challenges. According to Lingga (2002), hydroponic systems enable plants to grow optimally by providing nutrients directly to the root zone, thereby improving nutrient absorption efficiency. This characteristic makes hydroponics particularly suitable for leafy vegetables with rapid vegetative growth cycles. Sutiyoso (2006) emphasized that simple hydroponic systems can be developed using locally available materials, making them accessible for small-scale farmers and training institutions. These systems are not only intended for production purposes but also function as effective learning media for introducing modern cultivation technologies.

Rosliani and Sumarni (2005) reported that leafy vegetables cultivated using hydroponic techniques generally exhibit better hygiene and lower incidence of soil-borne diseases compared to conventional cultivation. Reduced exposure to pathogens contributes to healthier plant growth and minimizes the need for chemical control. Several studies have highlighted the importance of applied hydroponic implementation in agricultural training centers. FAO (2017) noted that practical, field-based learning approaches play a critical role in technology adoption among farmers. In this context, P4S institutions serve as strategic platforms for demonstrating environmentally friendly cultivation practices.

Hydroponic cultivation systems are generally classified into several types, including wick systems, nutrient film technique (NFT), deep flow technique (DFT), drip irrigation systems, and floating raft systems. Each system has different characteristics regarding water circulation, oxygen availability, and operational complexity. For training purposes, simple hydroponic systems are often preferred because they are easier to construct, require lower maintenance, and provide practical learning experiences for beginners. Their simplicity allows trainees to understand the basic principles of hydroponic cultivation before progressing to more advanced systems.

The success of hydroponic cultivation is influenced by several environmental factors, including nutrient concentration, pH level, dissolved oxygen, temperature, and light intensity. Maintaining these parameters within the optimum range ensures efficient nutrient absorption and healthy root development. Previous studies have shown that improper nutrient management may reduce plant growth even when hydroponic facilities are available. Therefore, regular monitoring of nutrient solution quality is considered one of the most important management practices in hydroponic production.

Previous research on hydroponic cultivation of water spinach has primarily focused on experimental yield comparisons and nutrient formulation trials (Nazaruddin, 2003). However, limited attention has been given to implementation-based evaluations that emphasize cultivation processes, technical constraints, and learning outcomes. This gap forms the basis for the novelty of the present study, which focuses on the applied implementation of a simple hydroponic system at the P4S scale.

METHODOLOGY

This study employed a descriptive qualitative approach focusing on the field implementation of a simple hydroponic system for water spinach cultivation. The implementation activities were conducted at P4S Sedana Sari in mid-2024. Data were collected through direct field observations covering all cultivation stages, including seedling preparation, transplanting, plant maintenance, nutrient management, and pest and disease control. Observations focused on visual plant conditions, cultivation practices, and technical constraints encountered during the implementation process. Data analysis was carried out descriptively by interpreting field observations and relating them to relevant concepts and findings reported in scientific literature. This approach was chosen to provide an applied and contextual understanding of the hydroponic implementation process.

The hydroponic system utilized simple cultivation equipment consisting of plastic nutrient reservoirs, PVC pipes, net pots, rockwool growing media, water pumps, and commercial hydroponic nutrient solution (AB Mix). Water spinach seeds were germinated on moist rockwool cubes before being transferred into the hydroponic channels after sufficient root development. Routine observations were conducted throughout the cultivation period to monitor plant growth, nutrient conditions, and system performance. To ensure the credibility of the findings, repeated observations were carried out during different growth stages. Observation notes were compared with cultivation guidelines and previous scientific publications to identify similarities and differences in implementation practices. This triangulation approach strengthened the interpretation of field observations and increased the reliability of the descriptive analysis.

RESEARCH RESULT

The implementation of a simple hydroponic system for water spinach (Ipomoea reptans) cultivation at P4S Sedana Sari showed generally positive outcomes throughout the cultivation period. Observations indicated that plant growth was relatively uniform across planting units, particularly during the vegetative phase. Leaves developed with a healthy green coloration, suggesting adequate nutrient uptake from the hydroponic solution. During the seedling stage, seeds germinated well when grown on rockwool media. The use of rockwool provided sufficient moisture retention and aeration for early root development. Most seedlings exhibited strong root formation before transplanting, which contributed to successful establishment in the hydroponic system.

Plant height increased steadily during the vegetative growth period, accompanied by continuous leaf formation and root elongation. Root systems appeared white and healthy throughout the cultivation process, indicating sufficient oxygen availability within the hydroponic environment. Healthy root development contributed to effective nutrient absorption and overall plant vigor. Water consumption remained relatively stable during the observation period, although a slight increase was observed as plant biomass expanded. Periodic addition of nutrient solution was necessary to compensate for water loss caused by evaporation and plant uptake. Regular monitoring prevented excessive fluctuations in nutrient concentration that could negatively affect plant performance.

Following transplanting, water spinach plants adapted quickly to the hydroponic environment. No significant transplant shock symptoms were observed, such as wilting or delayed growth. This condition indicates that the transition from seedling media to the hydroponic system was well managed. Nutrient management played a critical role in supporting plant growth. The hydroponic nutrient solution supplied essential macro- and micronutrients required for vegetative development. Throughout the observation period, plants did not show visible signs of nutrient deficiency, such as chlorosis or stunted growth. This suggests that the nutrient concentration was within an acceptable range for water spinach cultivation.

In terms of pest and disease incidence, the hydroponic system demonstrated relatively low disturbance. No major pest attacks were observed, and disease symptoms commonly associated with soil-based cultivation were absent. This condition contributed to cleaner plant appearance and reduced maintenance requirements. Several technical constraints were identified during implementation. Nutrient circulation relied on manual monitoring, which required consistent attention to maintain optimal conditions. Additionally, uneven nutrient distribution occasionally occurred due to system design limitations. Despite these technical limitations, participants involved in the implementation activities were able to understand the operational principles of hydroponic cultivation through direct practice. The implementation process encouraged active participation in preparing the system, monitoring plant growth, and evaluating cultivation outcomes. Such practical involvement strengthened participants' technical understanding beyond theoretical classroom learning. Despite these challenges, the system remained functional and suitable for small-scale cultivation and training activities at P4S Sedana Sari.

Harvest observations indicated that most plants reached marketable size within the expected cultivation period for water spinach. Plants exhibited tender stems, broad green leaves, and relatively uniform canopy development. Although quantitative measurements were not the primary focus of this study, visual observations suggested that overall crop performance met the standards generally expected for leafy vegetable production under simple hydroponic conditions. Participants also reported positive impressions regarding the cleanliness of harvested vegetables, as plants were free from attached soil particles commonly found in conventional cultivation systems. The implementation process additionally provided opportunities for participants to improve their technical understanding of hydroponic cultivation. Through routine observation and maintenance activities, participants became familiar with nutrient preparation procedures, water level monitoring, seedling management, and basic troubleshooting techniques. This practical experience enhanced participant confidence in operating hydroponic systems independently and demonstrated the effectiveness of hydroponics as a training medium within P4S programs.

DISCUSSION

The results of this study indicate that a simple hydroponic system can effectively support the growth of water spinach under limited land conditions. The uniform vegetative growth observed aligns with the fundamental principles of hydroponic cultivation, which emphasize direct nutrient availability to plant roots. Lingga (2002) stated that hydroponic systems allow plants to absorb nutrients more efficiently compared to soil-based systems, which may explain the consistent growth patterns observed in this study. The successful germination and seedling establishment observed in this implementation are consistent with findings reported by Sutiyoso (2006), who emphasized the importance of appropriate growing media in hydroponic systems. Rockwool, as used in this study, provides a stable environment for root development by maintaining moisture balance and oxygen availability. This condition is particularly important during the early growth stages of leafy vegetables such as water spinach. The findings also demonstrate that hydroponic cultivation provides greater control over environmental conditions than conventional soil cultivation. Since nutrients are delivered directly to the root zone, plant growth becomes less dependent on variations in soil fertility. This management flexibility enables growers to adjust nutrient supply according to crop growth stages, thereby improving cultivation efficiency.

Rapid plant adaptation following transplanting suggests that water spinach possesses high physiological adaptability to soilless cultivation systems. Nazaruddin (2003) noted that water spinach is a fast-growing vegetable that responds well to adequate nutrient supply. The absence of transplant shock symptoms further supports the suitability of hydroponic systems for cultivating this crop. Nutrient availability was a key factor influencing plant performance. The absence of visible nutrient deficiency symptoms indicates that the nutrient solution provided sufficient essential elements for vegetative growth. This finding supports Lingga's (2002) assertion that balanced nutrient composition is a critical determinant of hydroponic success. However, the reliance on manual nutrient monitoring highlights a potential limitation for system scalability. More advanced monitoring tools could improve nutrient stability and reduce labor requirements.

Hydroponic cultivation also offers several environmental advantages compared to conventional soil-based agriculture. Water is continuously recirculated within the cultivation system, allowing more efficient utilization than traditional irrigation methods where considerable amounts of water may be lost through runoff or deep percolation. This characteristic is particularly important in regions experiencing increasing pressure on freshwater resources. Moreover, because nutrient solutions are supplied directly to plant roots, fertilizer application becomes more precise, reducing nutrient losses to the surrounding environment. Such efficiency contributes to environmentally sustainable agricultural production while maintaining satisfactory plant growth.

The low incidence of pests and diseases observed in this study is consistent with previous research indicating that hydroponic systems reduce exposure to soil-borne pathogens. Rosliani and Sumarni (2005) reported that leafy vegetables grown using hydroponic techniques tend to experience fewer disease problems compared to conventional soil cultivation. This advantage contributes to improved crop hygiene and reduced need for chemical pest control. Another important advantage observed during this implementation was the relatively clean working environment. Unlike conventional cultivation, hydroponic systems generated minimal soil waste and reduced weed growth, thereby decreasing labor requirements for maintenance. These practical benefits enhance the attractiveness of hydroponic technology for educational demonstrations and urban agriculture initiatives. Despite the positive outcomes, the technical limitations identified in this implementation should be considered. Uneven nutrient distribution due to system design constraints may affect plant growth uniformity if not properly managed. Sutiyoso (2006) emphasized that system design and nutrient circulation efficiency are essential for optimizing hydroponic performance. Therefore, system improvements are necessary if hydroponic cultivation is to be expanded beyond training-scale applications.

From the perspective of agricultural extension, demonstration-based learning has been recognized as one of the most effective approaches for transferring agricultural innovations. Participants who directly observe crop growth and management practices generally develop a better understanding of cultivation techniques compared to those receiving theoretical instruction alone. Therefore, implementing hydroponic systems within P4S institutions may accelerate the dissemination of sustainable cultivation technologies to surrounding farming communities.

Although this study adopted a descriptive qualitative approach, the implementation results provide valuable baseline information for future quantitative investigations. Parameters such as plant height, leaf number, fresh biomass, nutrient use efficiency, and economic feasibility could be incorporated into subsequent studies to strengthen scientific evidence regarding the effectiveness of simple hydroponic systems.

From an applied perspective, the implementation of a simple hydroponic system at P4S Sedana Sari demonstrates its potential as an effective learning model. The system allows trainees to observe plant responses directly and understand the relationship between nutrient management and plant growth. This practical learning value represents an important contribution of this study, distinguishing it from purely experimental research. Overall, the findings of this study confirm that simple hydroponic systems can serve as viable alternatives for water spinach cultivation in land-limited settings. When managed properly, such systems can support healthy plant growth, reduce pest and disease risks, and provide valuable educational benefits.

The educational value of the implementation should also be emphasized. Participants were involved directly in every cultivation stage, beginning with seed germination, transplanting, nutrient preparation, daily maintenance, and harvesting. Such hands-on experience enables trainees to develop technical competence through experiential learning rather than relying solely on classroom instruction. Practical involvement also encourages problem-solving skills, as trainees learn to identify nutrient deficiencies, monitor water quality, and respond to technical challenges during cultivation. This experiential learning approach is consistent with agricultural extension principles that emphasize learning by doing as an effective strategy for technology dissemination.

Furthermore, the implementation of hydroponic technology supports broader agricultural development objectives related to climate resilience and sustainable food production. Hydroponic cultivation is less dependent on soil quality, allowing vegetable production in areas affected by soil degradation or urban expansion. As climate variability increasingly influences agricultural productivity, controlled cultivation systems such as hydroponics may become valuable alternatives for maintaining stable vegetable supplies throughout the year. Therefore, introducing hydroponic technology through agricultural training institutions can contribute not only to capacity building but also to long-term agricultural resilience.

CONCLUSIONS AND RECOMMENDATIONS

The implementation also demonstrated that hydroponic technology can function not only as a production system but also as an effective educational medium for developing practical agricultural skills. Through direct participation in system construction, nutrient preparation, and plant maintenance, trainees acquired hands-on experience that may improve their confidence in adopting hydroponic technology independently.

The implementation of a simple hydroponic system at P4S Sedana Sari demonstrated its effectiveness in supporting water spinach cultivation under limited land conditions. The system was able to support healthy plant growth and reduce pest and disease risks, making it suitable for educational and limited production purposes. It is recommended that future implementations focus on improving nutrient circulation and monitoring techniques to enhance system efficiency. Strengthening technical management will support broader application and sustainability of hydroponic systems at the community level.

The findings of this study have practical implications for agricultural extension services, vocational education institutions, and community empowerment programs. The implementation of simple hydroponic systems demonstrates that modern cultivation technology can be introduced using relatively affordable materials without requiring extensive agricultural land. This approach is particularly relevant for urban and peri-urban communities where land resources are increasingly limited. For P4S institutions, hydroponic cultivation provides an interactive learning model that integrates theoretical knowledge with practical application. Participants are able to develop technical competencies related to seedling production, nutrient management, plant maintenance, and problem-solving under real cultivation conditions. Consequently, hydroponic demonstrations may strengthen agricultural training programs while promoting environmentally sustainable food production practices.

ADVANCED RESEARCH

Further studies are recommended to evaluate hydroponic system performance using quantitative growth parameters and to compare hydroponic cultivation with conventional soil-based systems. Such research would provide a more comprehensive understanding of productivity and efficiency differences across cultivation methods.

REFERENCES

FAO. (2017). *The Future of Food and Agriculture: Trends and Challenges*. Rome: Food and Agriculture Organization.

Jones, J. B. (2005). *Hydroponics: A Practical Guide for the Soilless Grower*. Boca Raton: CRC Press.

Lingga, P. (2002). *Hidroponik: Bercocok Tanam Tanpa Tanah*. Jakarta: Penebar Swadaya.

Nazaruddin. (2003). *Budidaya Sayuran Dataran Rendah*. Jakarta: Penebar Swadaya.

Putra, A. R., & Yulianto, T. (2019). Application of hydroponic systems for leavegetables under limited land conditions. *Jurnal Hortikultura Indonesia*, 10(1), 45–53.

Rahmawati, N., & Handayani, S. (2020). Sustainable vegetable production using hydroponic systems. *Jurnal Pertanian Berkelanjutan*, 8(1), 22–31.

Raviv, M., & Lieth, J. H. (2008). *Soilless Culture: Theory and Practice*. Amsterdam: Elsevier.

Resh, H. M. (2013). *Hydroponic Food Production*. Boca Raton: CRC Press.

Rosliani, R., & Sumarni, N. (2005). *Budidaya Tanaman Sayuran dengan Teknik Hidroponik*. Bandung: Balai Penelitian Tanaman Sayuran.

Saptana, Daryanto, A., & Kuntjoro. (2020). Agricultural development and food security in Indonesia. *Journal of Agricultural Policy*, 18(2), 101–115.

Savvas, D., & Gruda, N. (2018). Application of soilless culture technologies in vegetable crop production. *European Journal of Horticultural Science*, 83(5), 280–293.

Setiawan, B., & Prasetyo, A. (2018). The role of training centers in agricultural technology dissemination. *Jurnal Agribisnis*, 12(3), 134–146.

Sutiyoso, Y. (2006). *Hidroponik Ala Yos*. Jakarta: Penebar Swadaya.

Utami, R., & Nugroho, B. (2022). Hydroponic cultivation as an alternative farming system in urban areas. *Jurnal Agroekoteknologi*, 14(2), 77–85.

Widodo, S., & Lestari, D. (2021). Hydroponic technology adoption among small-scale farmers. *Jurnal Penyuluhan Pertanian*, 16(2), 89–98.